

NEXRAD Technical Advisory Committee Meeting  
November 17, 2009



Performance Analysis (Informational Brief)

# CLUTTER ENVIRONMENT ANALYSIS USING ADAPTIVE PROCESSING (CLEAN-AP)

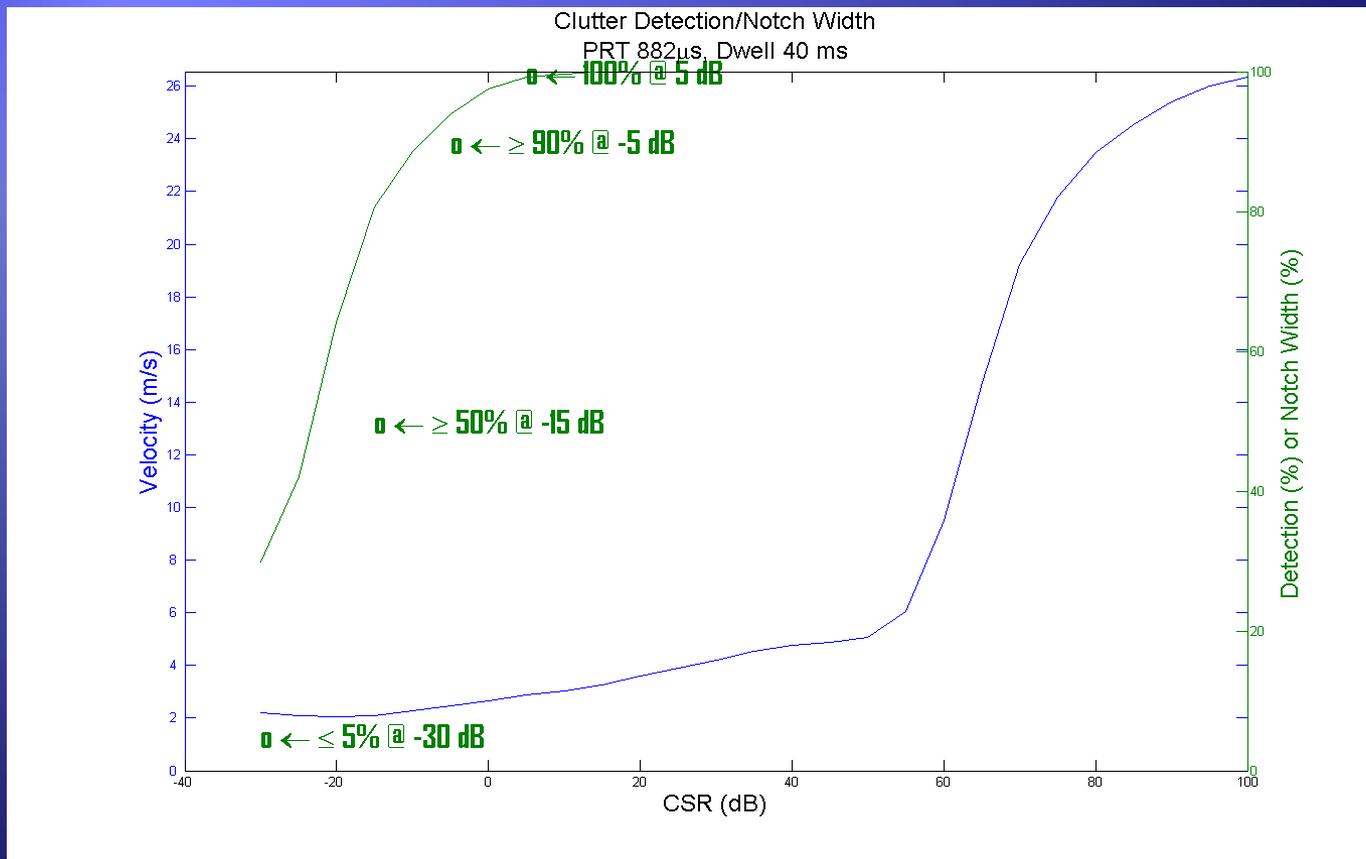
**DAVID WARDE AND SEBASTIAN TORRES**  
CIMMS/University of Oklahoma  
And NSSL/NOAA

# OUTLINE

- ◆ Simulation results
  - ◆ Clutter Detection
  - ◆ Clutter Filtering
- ◆ Real data analyses and comparisons
  - ◆ KEMX (Can you see the mountains?)
  - ◆ KABX (Are the mountains still there?)
  - ◆ KCRI (What happened to the zero-isodop?)
  - ◆ KTLX (Where is the zero?)
- ◆ Summary and recommendation

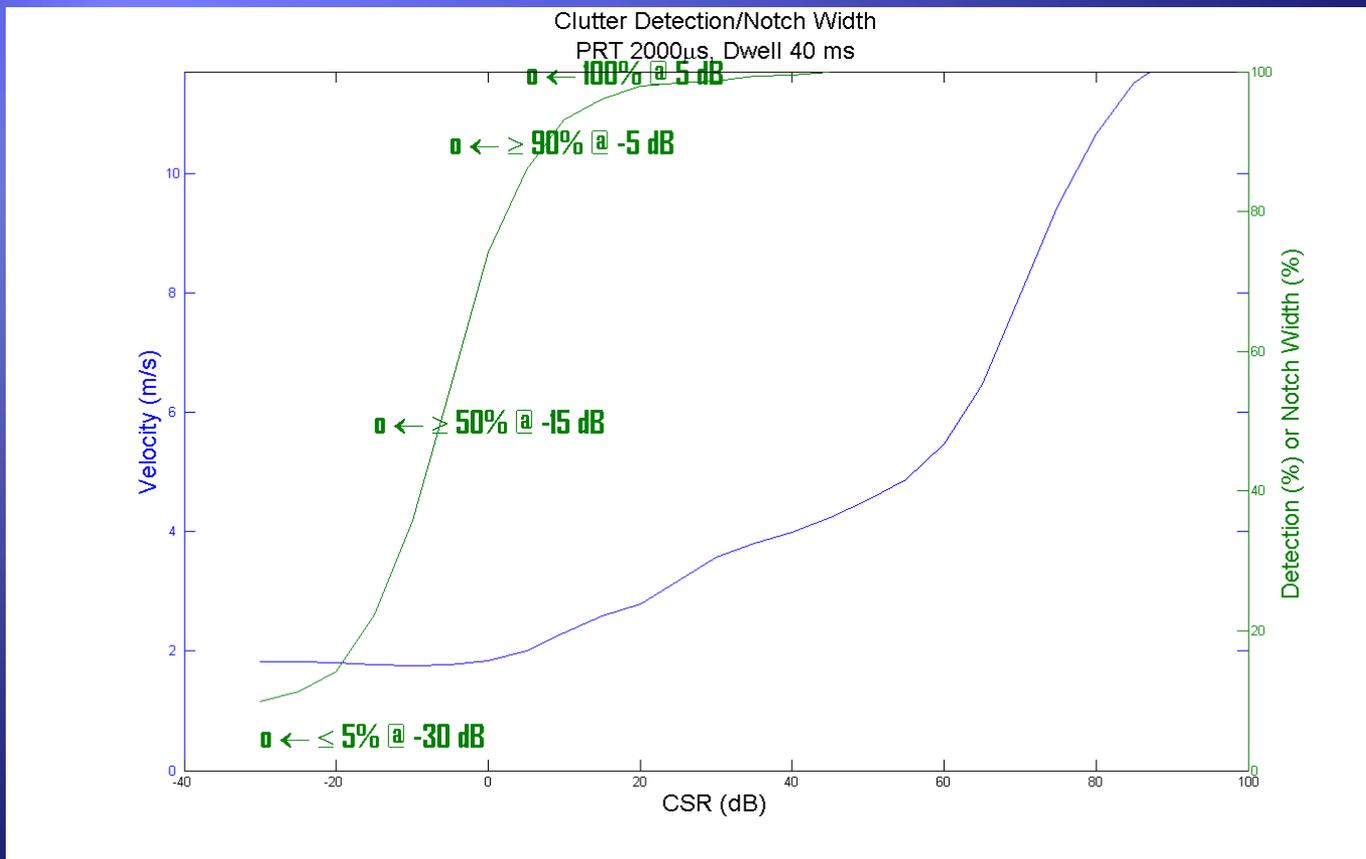
# Clutter Detection Performance

(SNR 20 dB, SW 4 m/s, Nyquist 26.6 m/s)



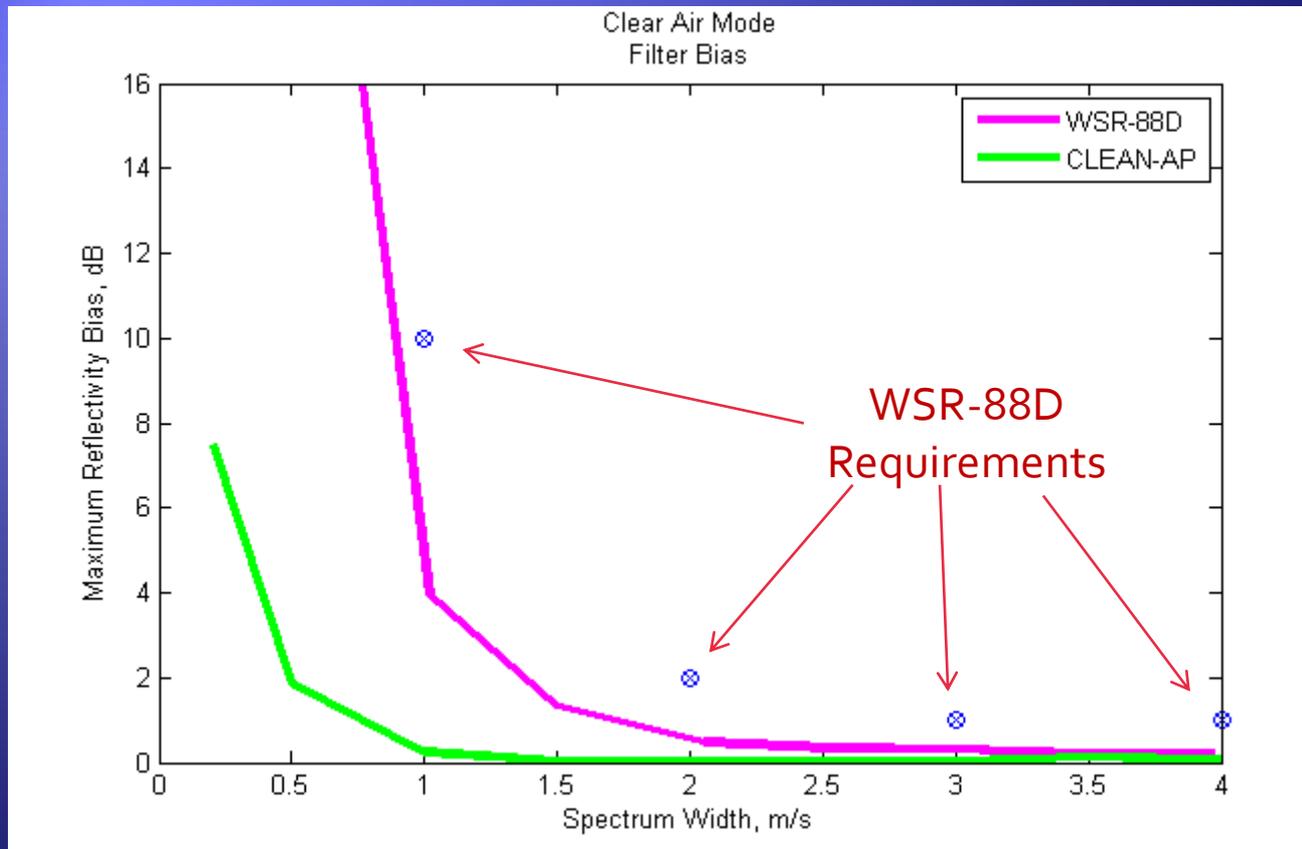
# Clutter Detection Performance

(SNR 20 dB, SW 4 m/s, Nyquist 11.7 m/s)



# Clutter Filtering

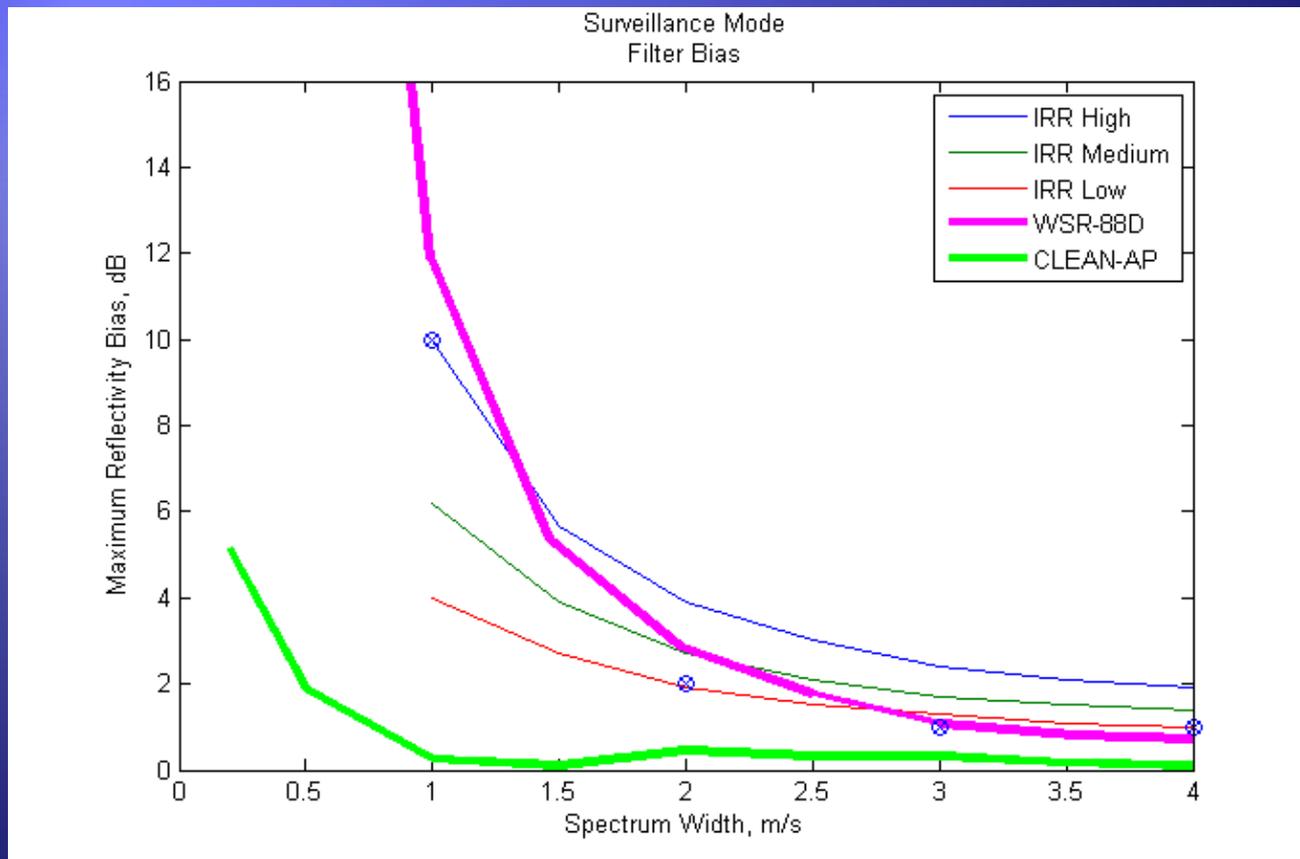
## Clear Air Reflectivity Bias



WSR-88D data from Ice et al. 2004

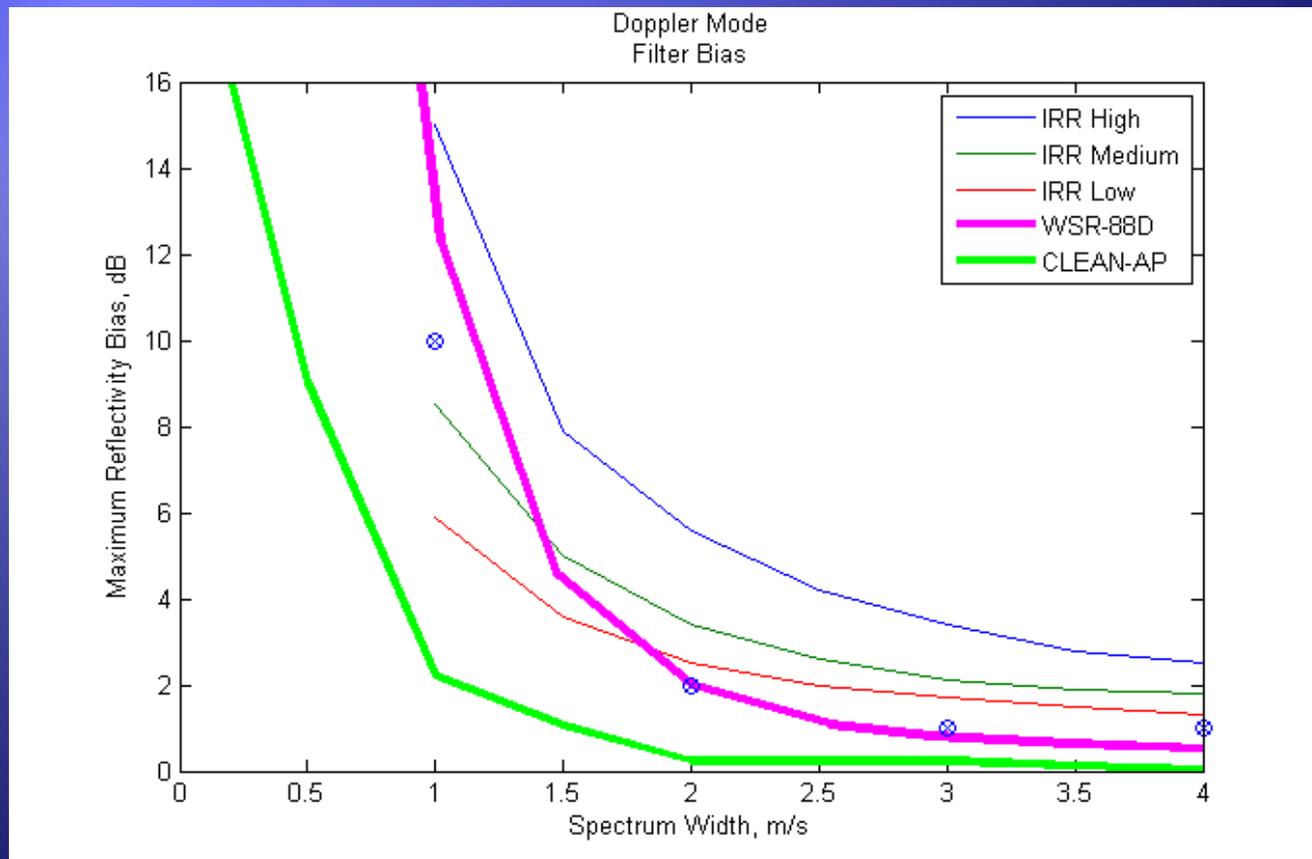
# Clutter Filtering

## Surveillance Reflectivity Bias



WSR-88D data from Ice et al. 2004

# Clutter Filtering Doppler Reflectivity Bias

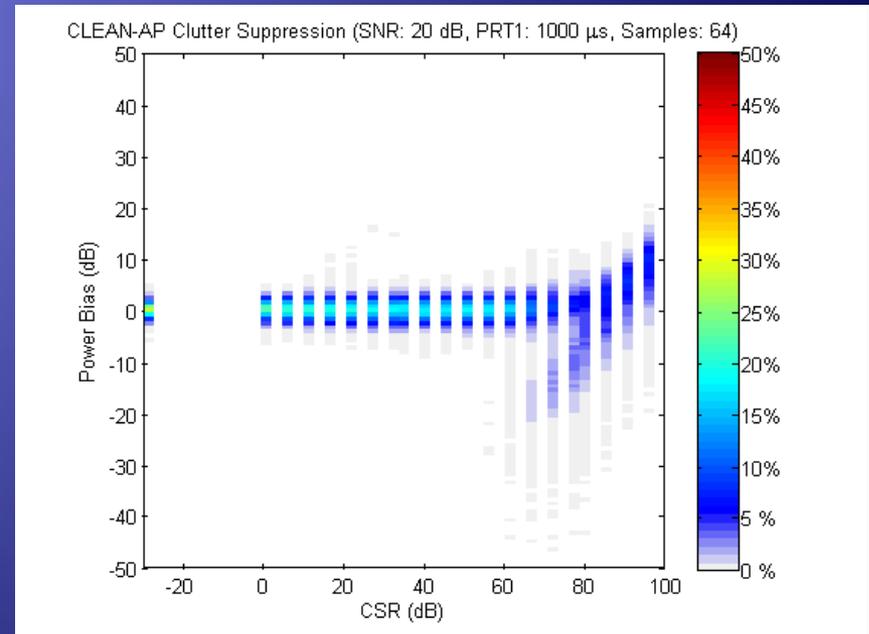
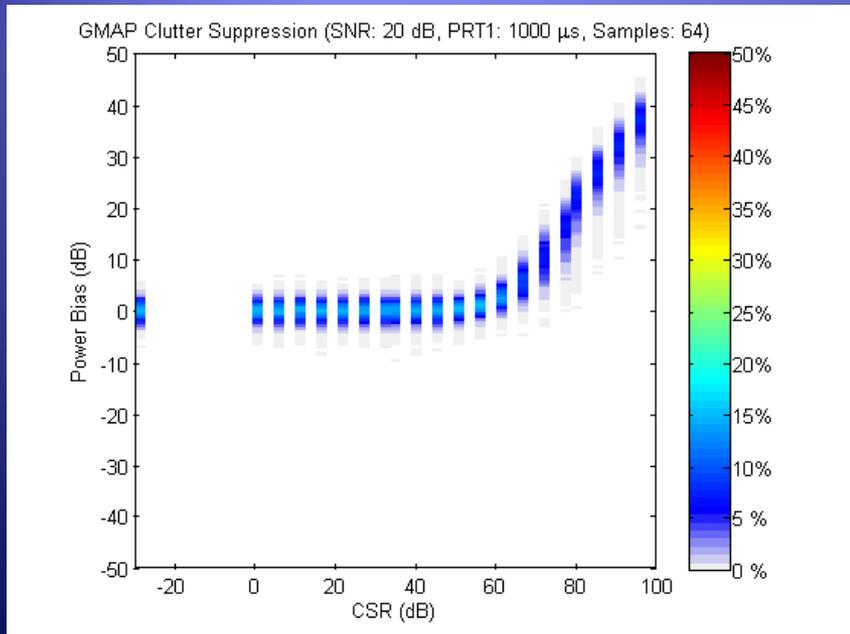


WSR-88D data from Ice et al. 2004

# Clutter Filtering Suppression Comparison

GMAP

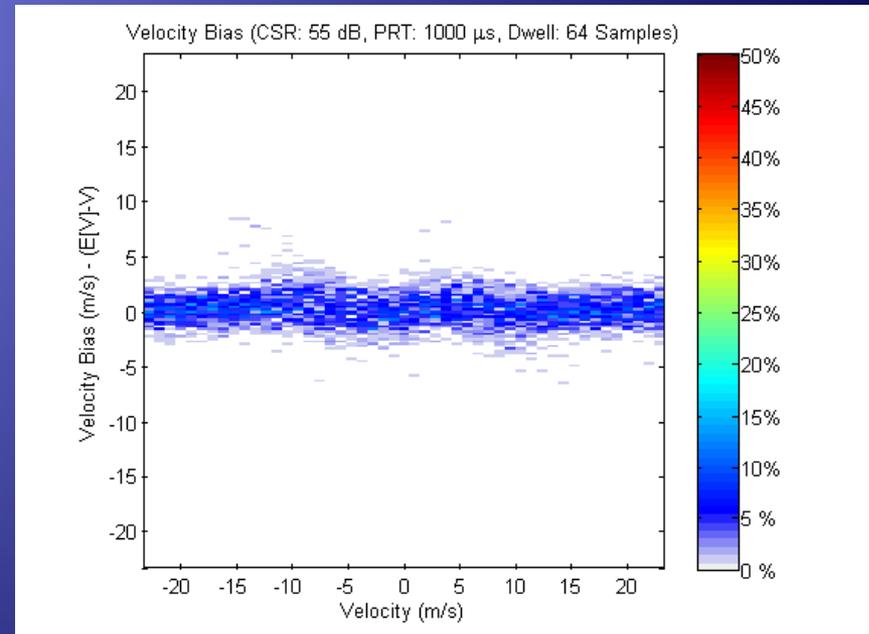
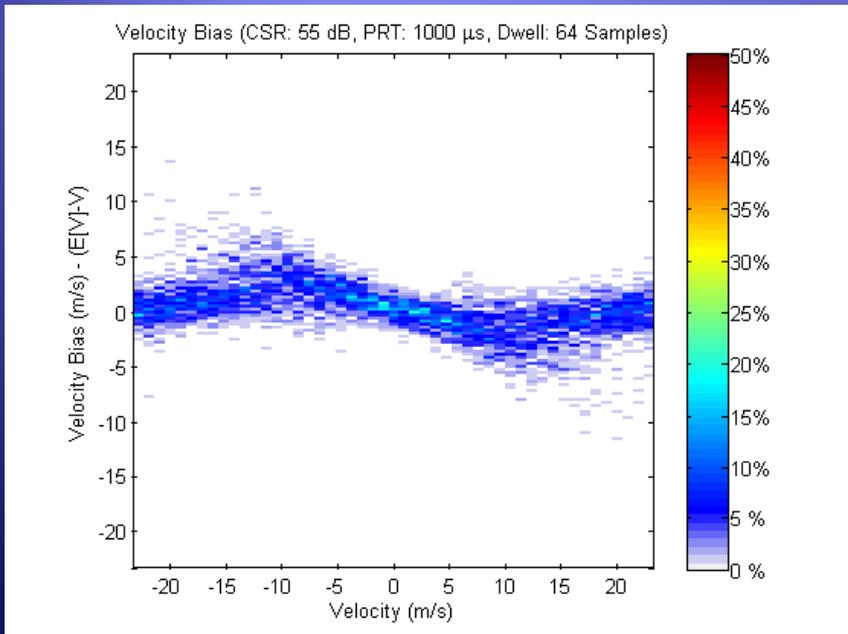
CLEAN-AP



# Clutter Filtering Velocity Bias Comparison

GMAP

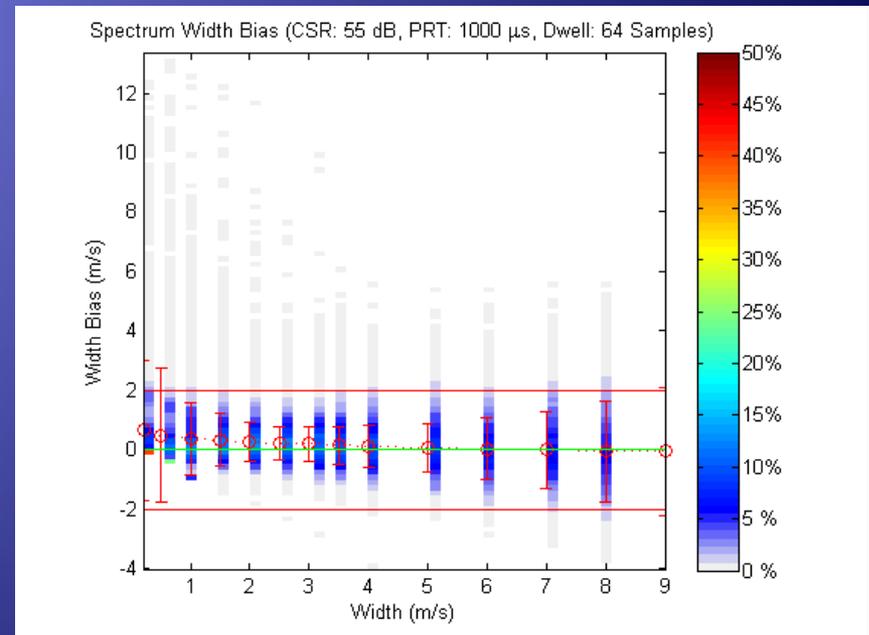
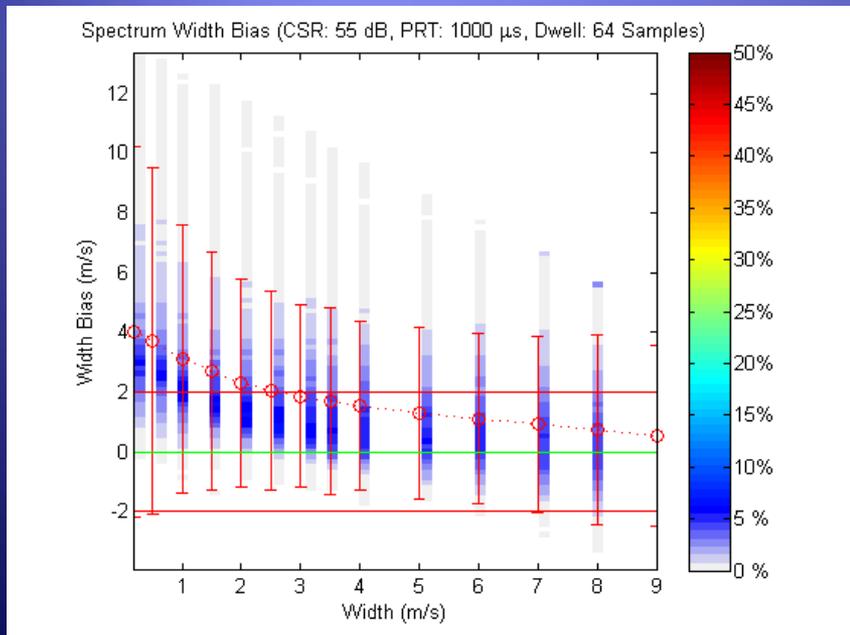
CLEAN-AP



# Clutter Filtering Spectrum Width Bias Comparison

GMAP

CLEAN-AP



# KEMX

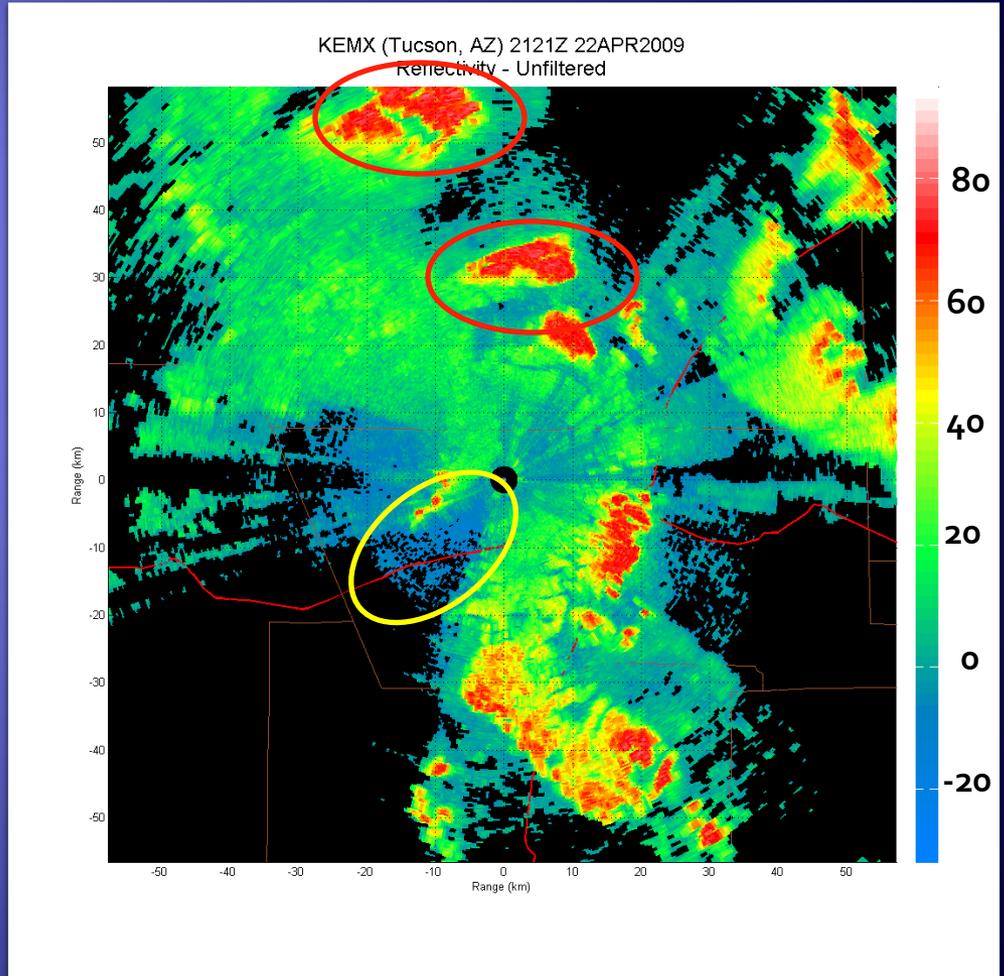
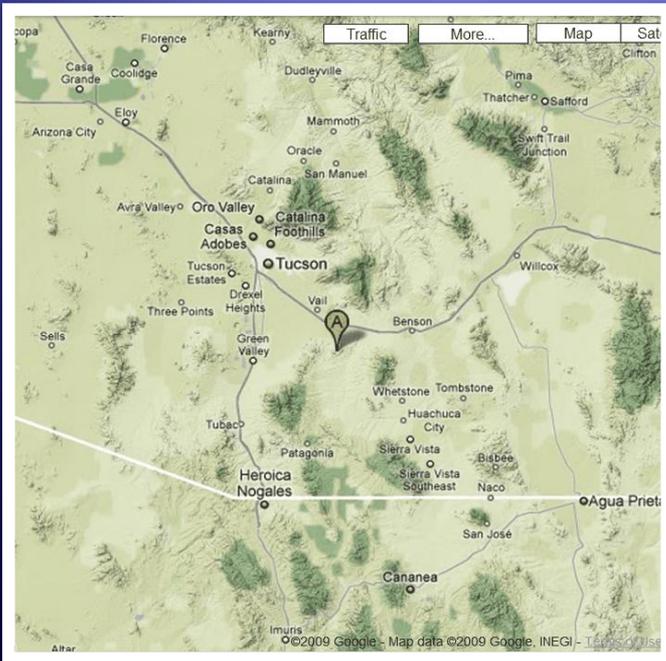
## Tucson, AZ

### Can you see the mountains?

- ◆ RDA Build 11.0 Beta Test (CMD implemented)
  - ◆ Missed CMD detections in RDA Build 11.0
    - ◆ Level-I data indicated that, at times, two distinct targets were captured by the moving antenna
    - ◆ Phase and power changes between clutter targets caused low CPA values
  - ◆ Mitigated CMD missed detections in RDA Build 11.1

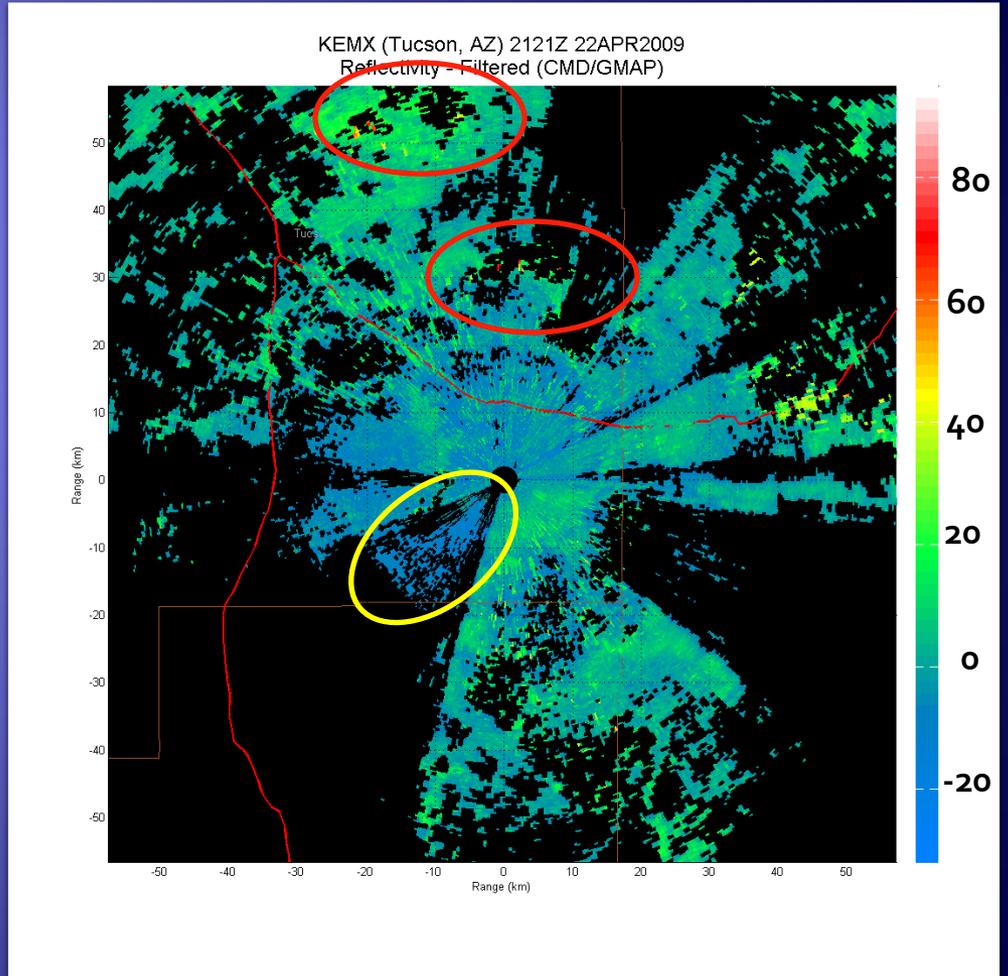
# KEMX

Mountainous Terrain  
And  
Low Level Clutter



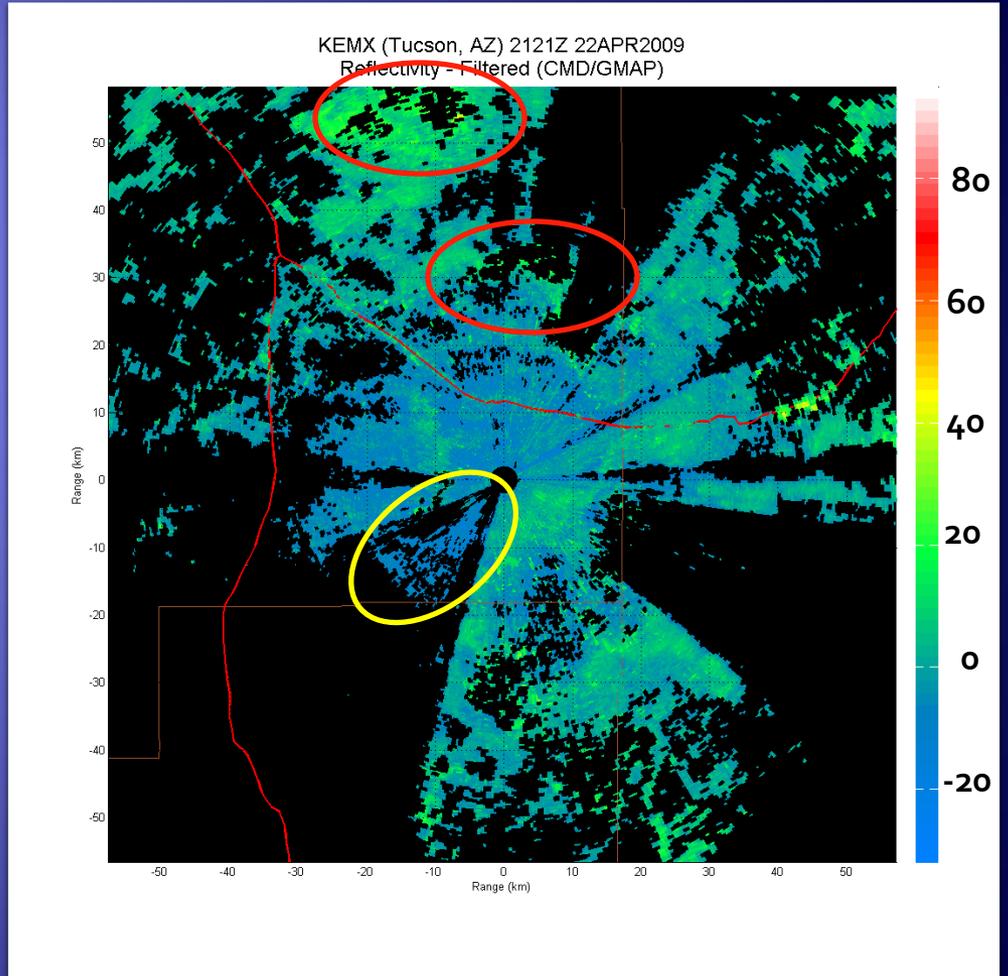
WSR-88D Located Southeast of Vail, AZ  
Mountainous terrain above Catalina Foothills

**KEMX**  
Build 11.0  
Hot Spots in Mountainous Terrain  
And  
Low Level Clutter



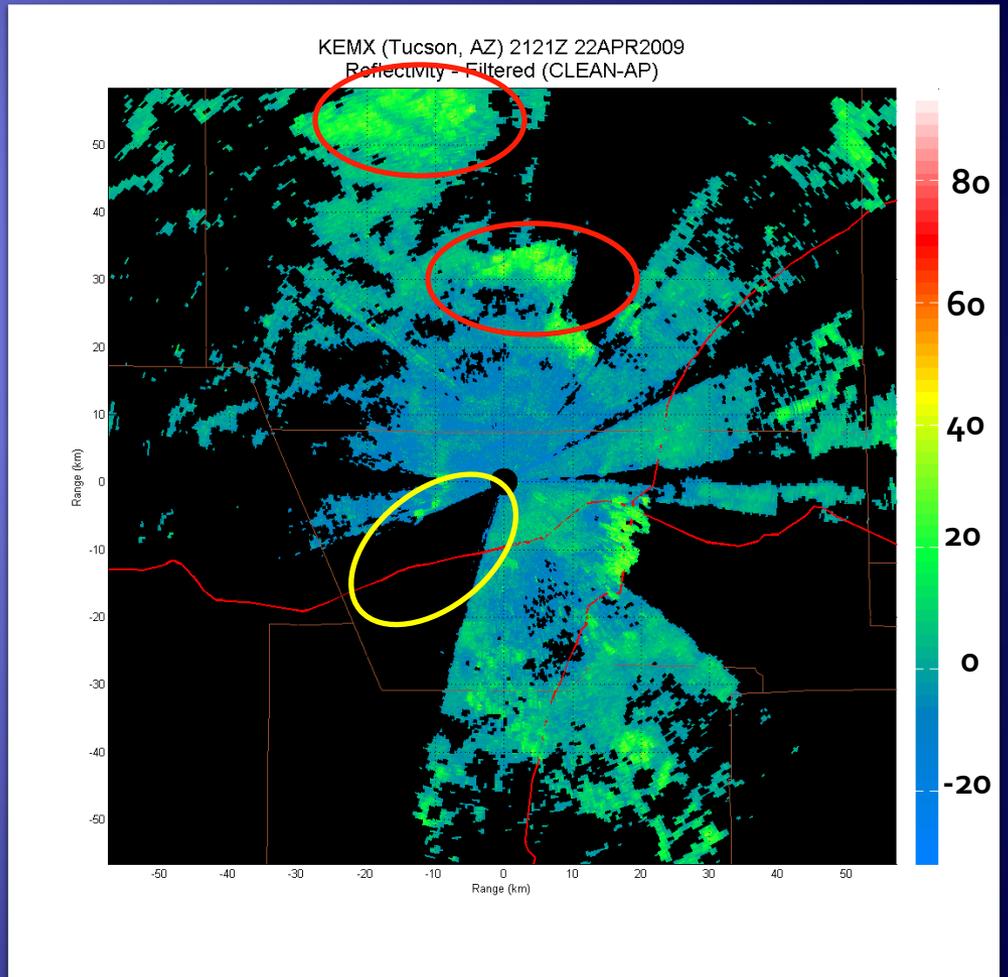
Data provided by ROC : Jane Krause

**KEMX**  
Build 11.1  
Hot Spots in Mountainous Terrain  
And  
Low Level Clutter



Data provided by ROC : Jane Krause

**KEMX**  
CLEAN-AP  
Hot Spots in Mountainous Terrain  
And  
Low Level Clutter



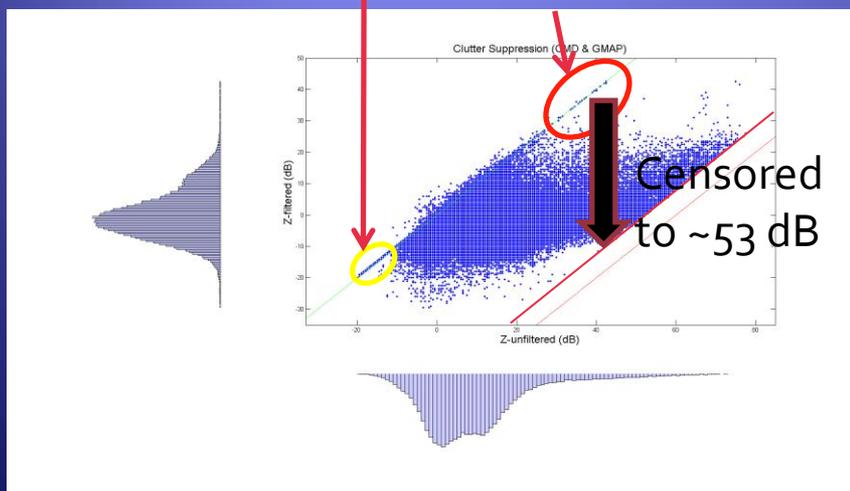
# KEMX

## Clutter Suppression

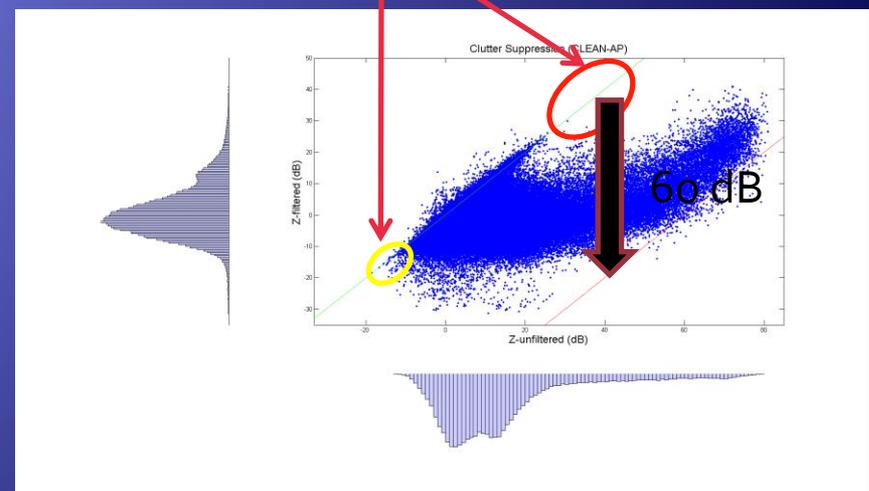
CMD & GMAP Build 11.1

CLEAN-AP

Missed Detections



Detected



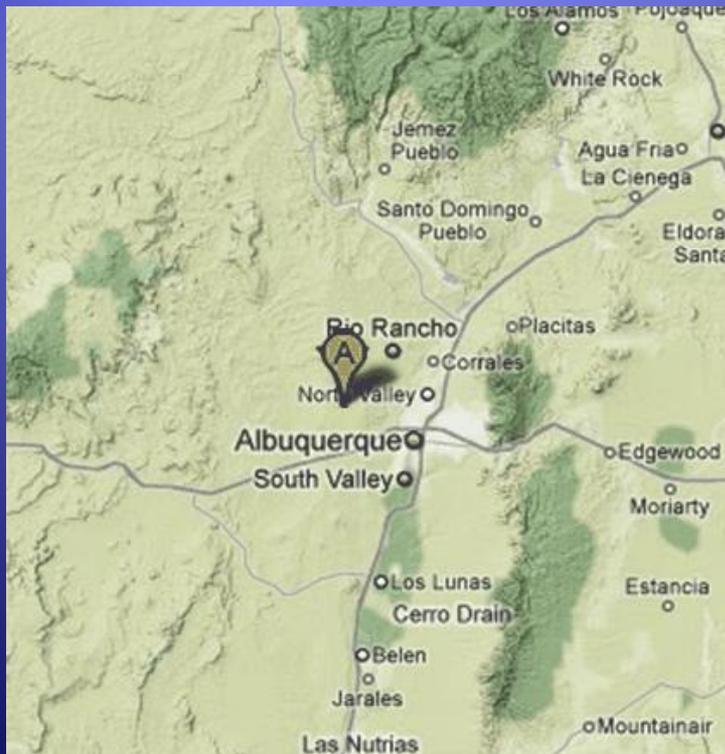
Data provided by ROC : Jane Krause

# KABX

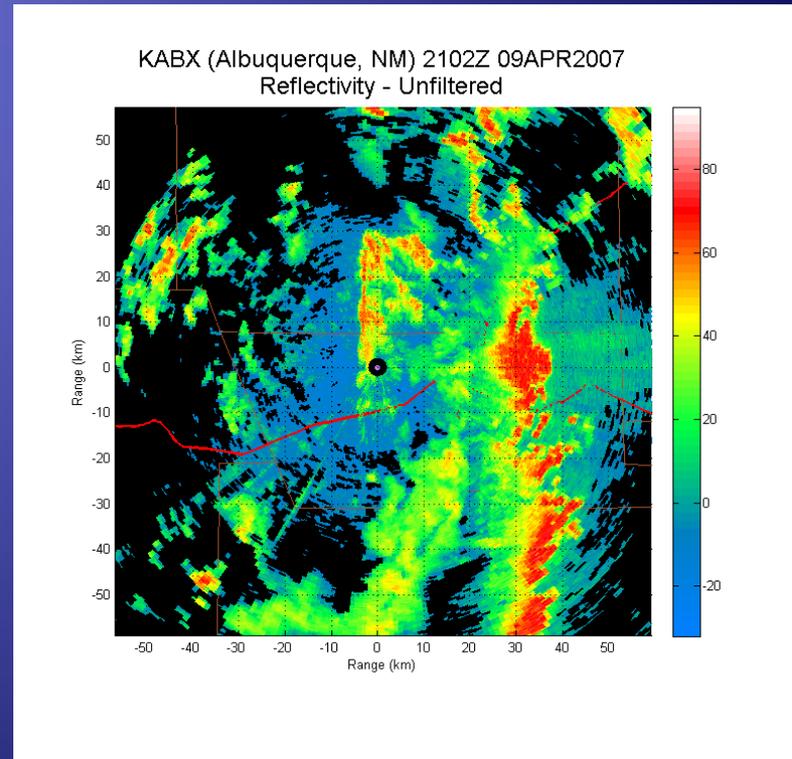
## Albuquerque, NM

### Are the mountains still there?

Terrain



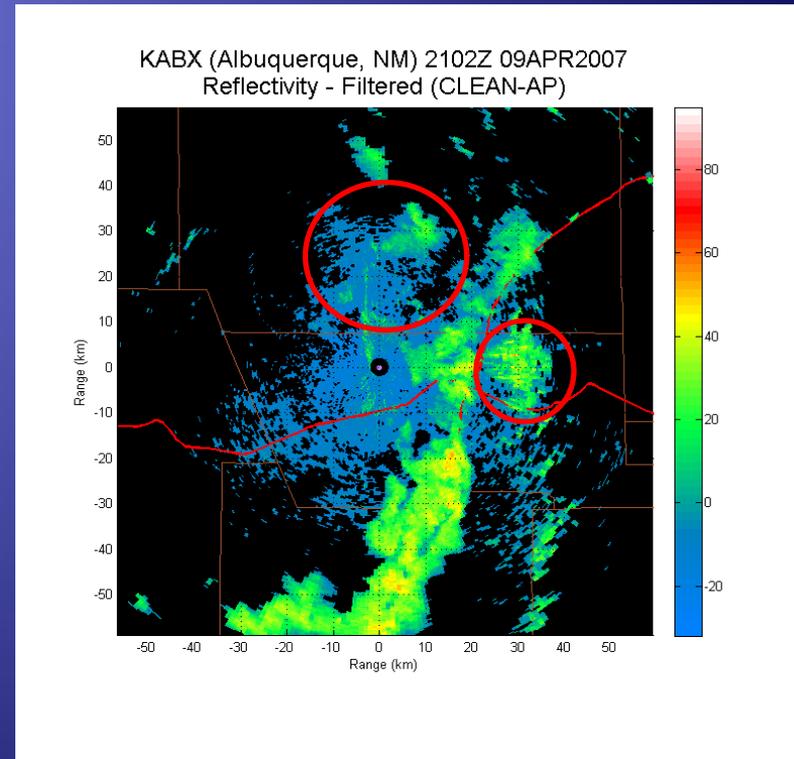
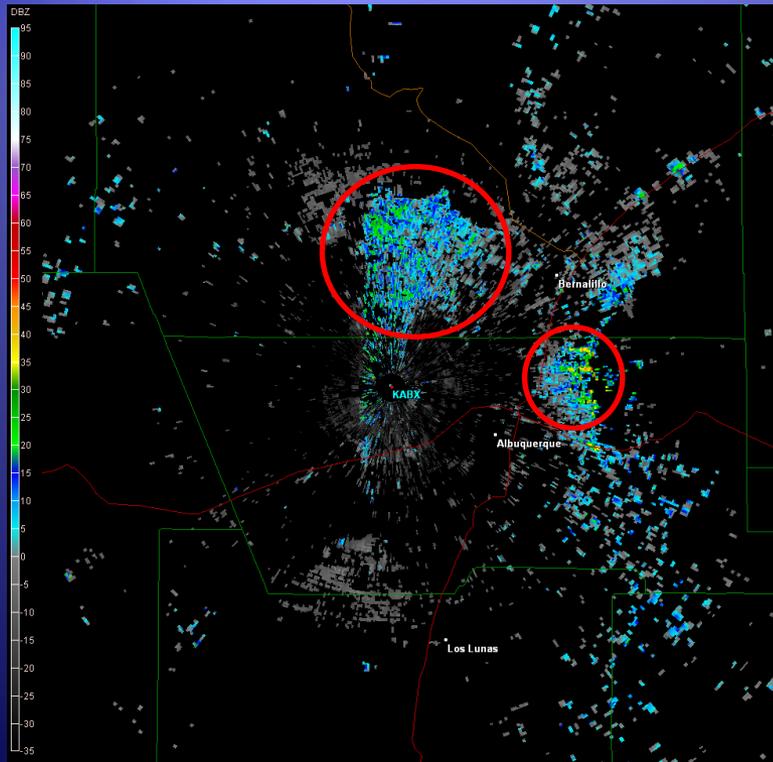
Unfiltered



# KABX Albuquerque, NM

CMD & GMAP Build 11.1

CLEAN-AP



November 16, 2009

# KCRI (ROC Testbed)

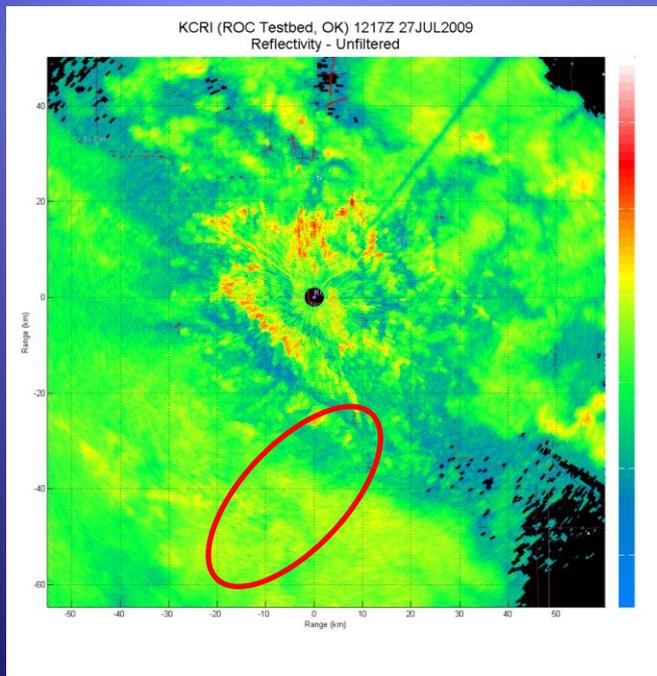
## Norman, OK

### What happened to the zero-isodop?

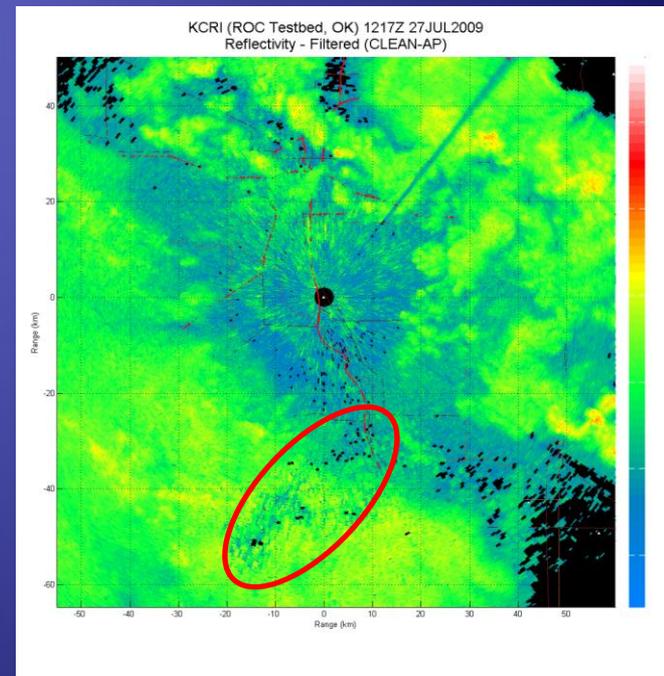
- ◆ Zero-isodop loss
  - ◆ Weather with narrow spectrum width and near zero velocity has nearly the same spectrum as clutter

# KCRI (ROC Testbed) Reflectivity

Unfiltered

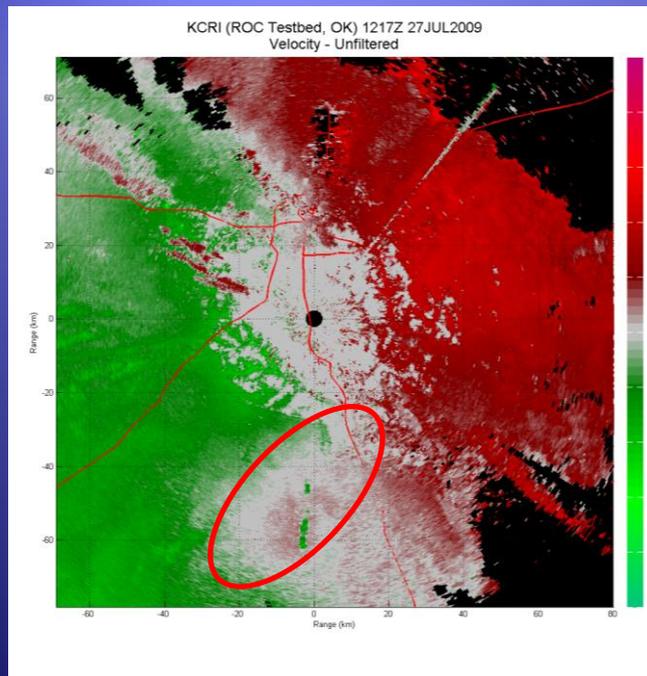


CLEAN-AP

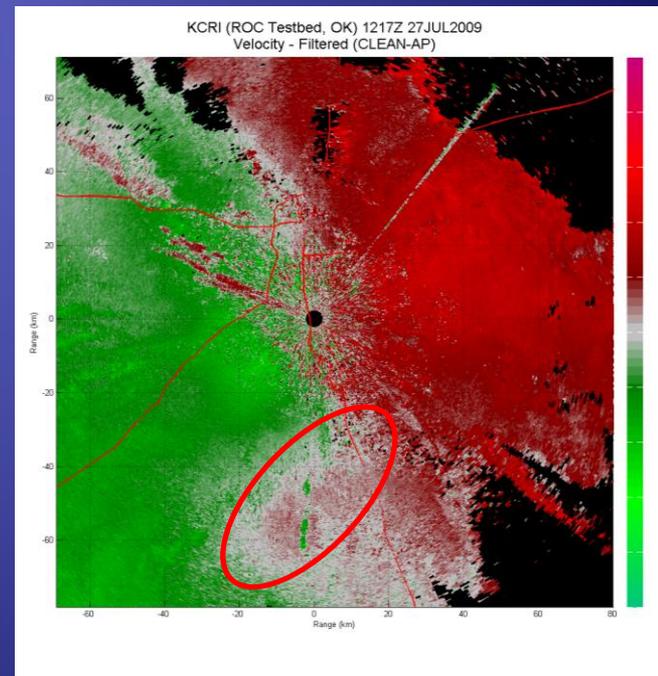


# KCRI (ROC Testbed) Velocity

Unfiltered



CLEAN-AP

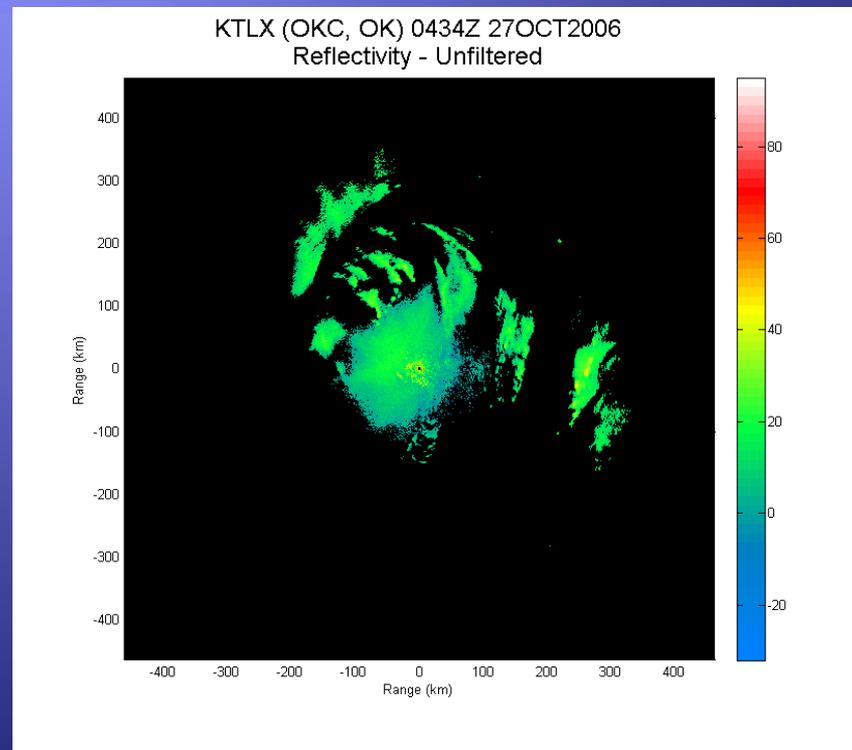


# KTLX

## Oklahoma City, OK

### Where is the zero?

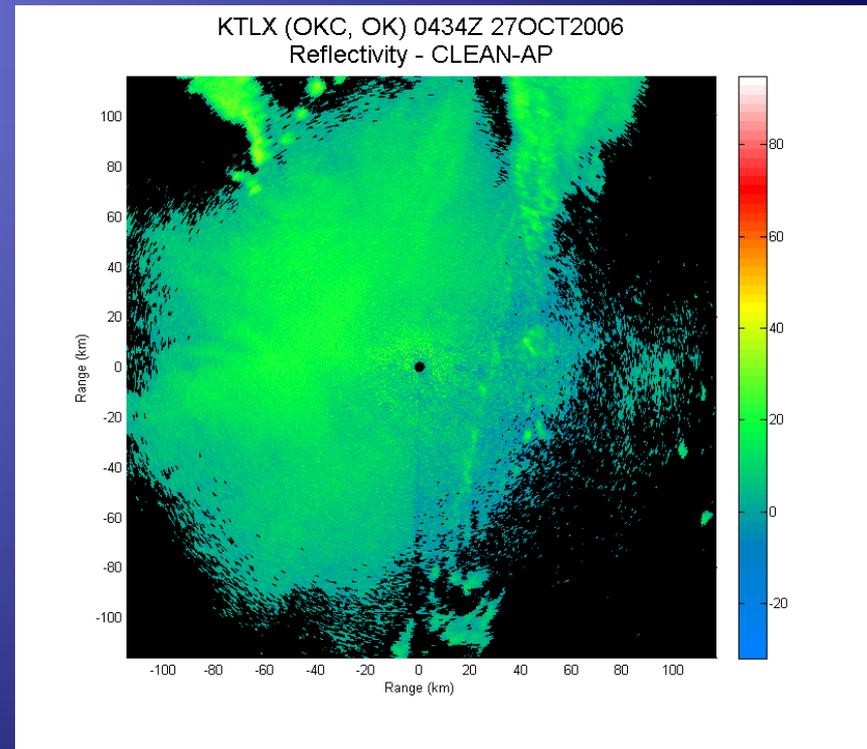
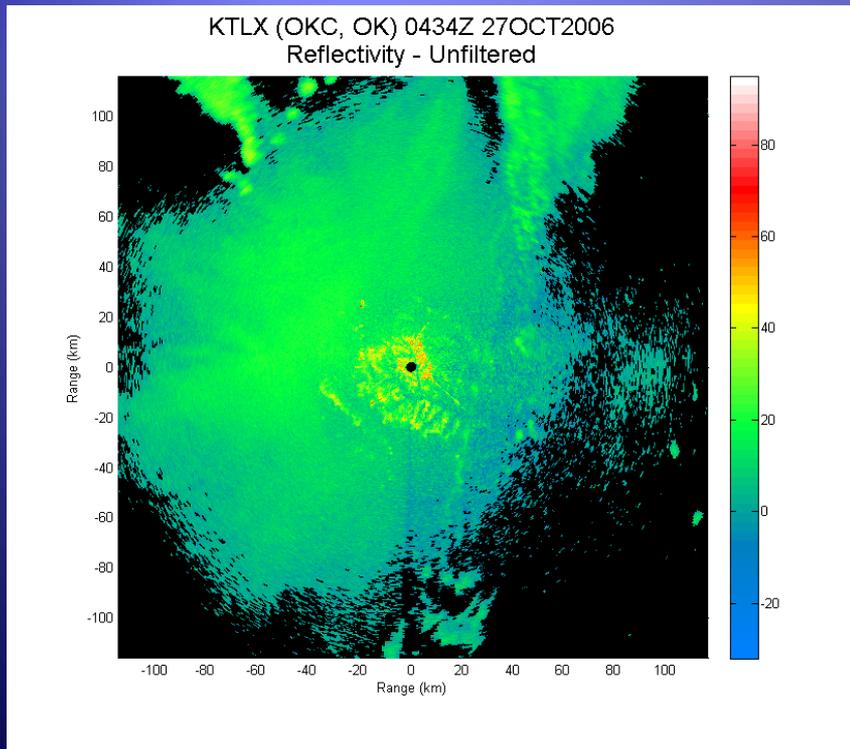
- ◆ Snow event with imbedded storms



# KTLX Reflectivity

Unfiltered

CLEAN-AP



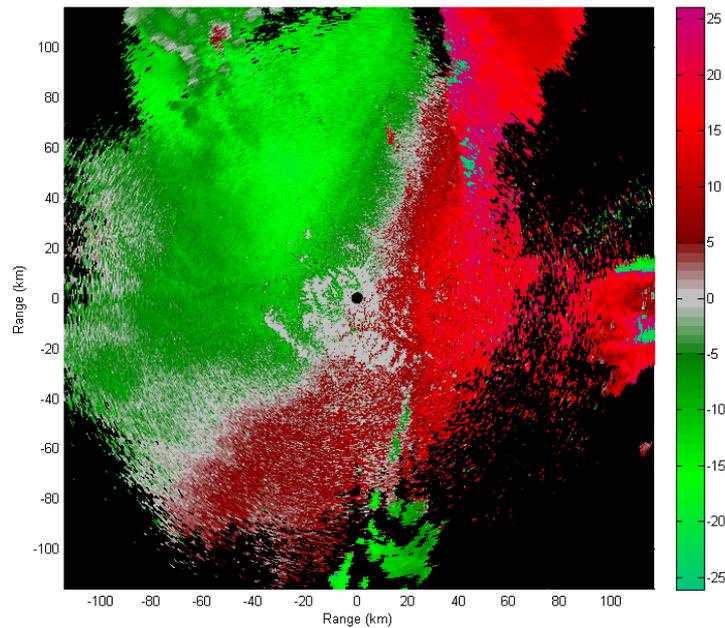
No detectable zero-isodop loss!

# KTLX Velocity

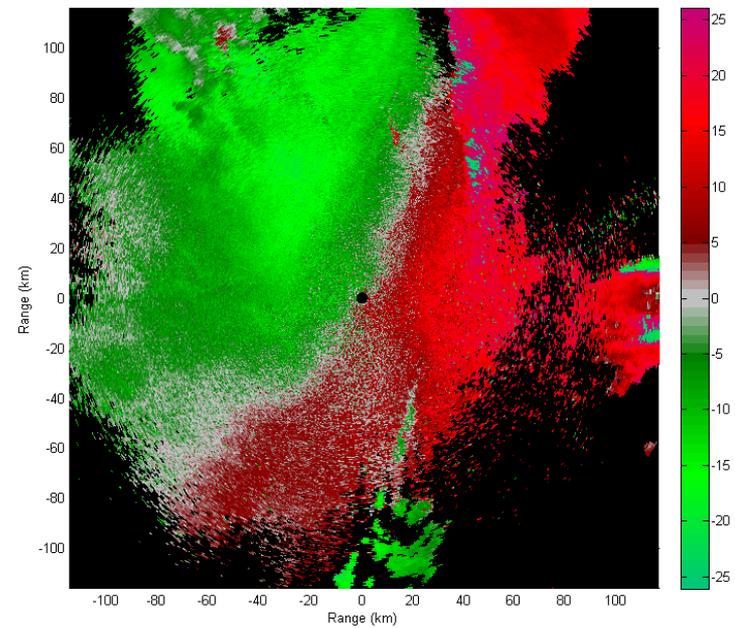
Unfiltered

CLEAN-AP

KTLX (OKC, OK) 0434Z 27OCT2006  
Velocity - Unfiltered



KTLX (OKC, OK) 0434Z 27OCT2006  
Velocity - CLEAN-AP

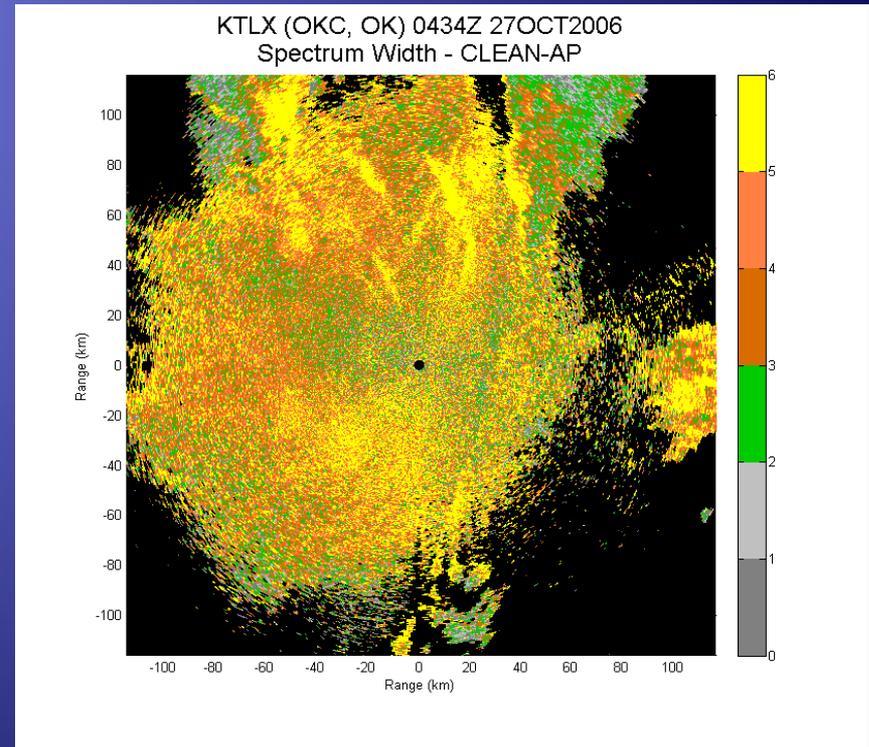
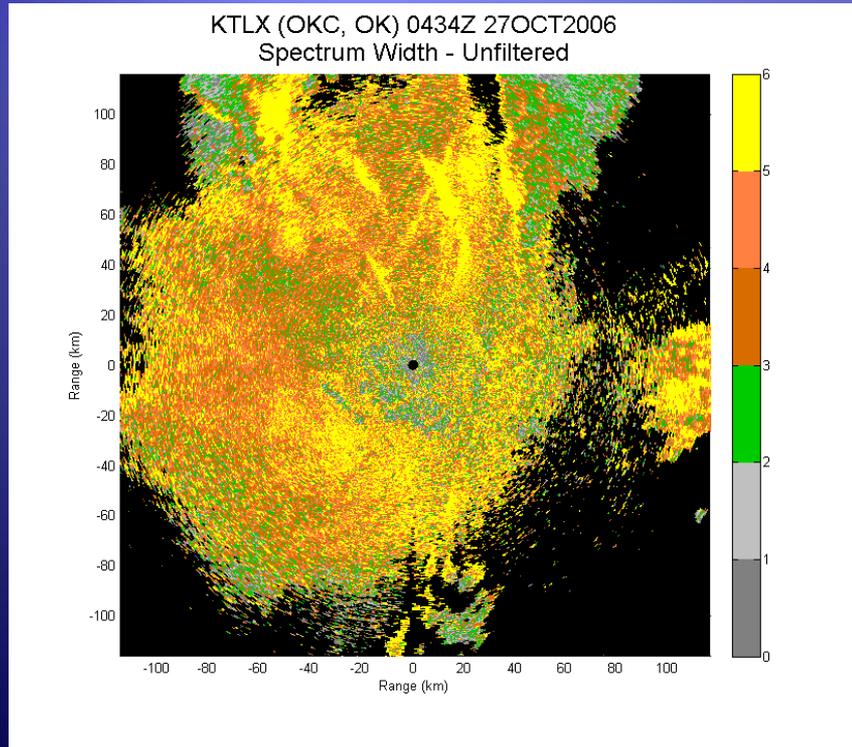


# KTLX

## Spectrum Width

Unfiltered

CLEAN-AP



PPP Processing

Cross-Spectral Processing

# Summary

- ◆ CLEAN-AP
  - ◆ Performance exceeds NEXRAD standards
  - ◆ Clutter Detection is comparable to CMD
    - ◆ Better performance in mountainous environments
    - ◆ Better performance in low clutter environments
  - ◆ Clutter Suppression exceeds GMAP
  - ◆ Better Data Quality

# Recommendation

- ◆ CLEAN-AP is a **real-time, automatic, integrated** approach for ground clutter **detection** and **filtering** that produces data with the **best possible quality** while meeting NEXRAD technical **requirements**
  - ◆ Improved performance compared to current approach
- ◆ We recommend considering the CLEAN-AP filter as a ground clutter mitigation solution for the NEXRAD network
  - ◆ TAC endorsement is needed

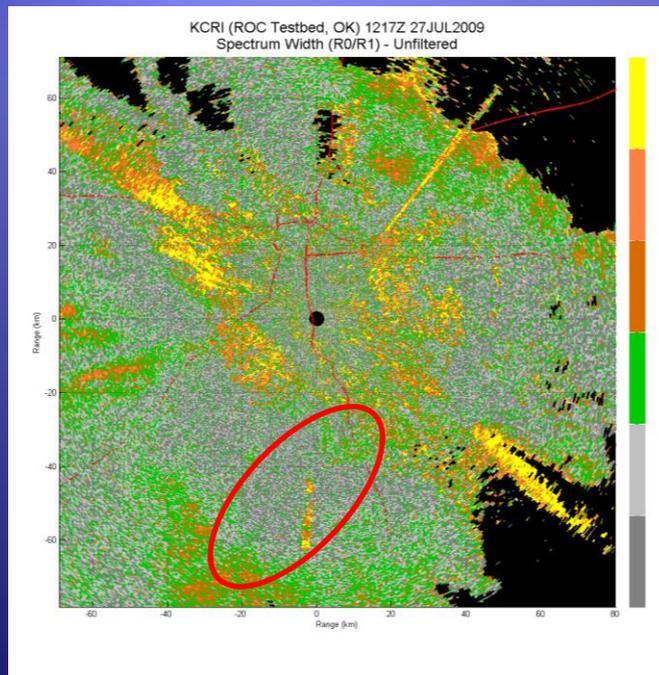
# BACK UP SLIDES

# Detection and Filtering Requirements

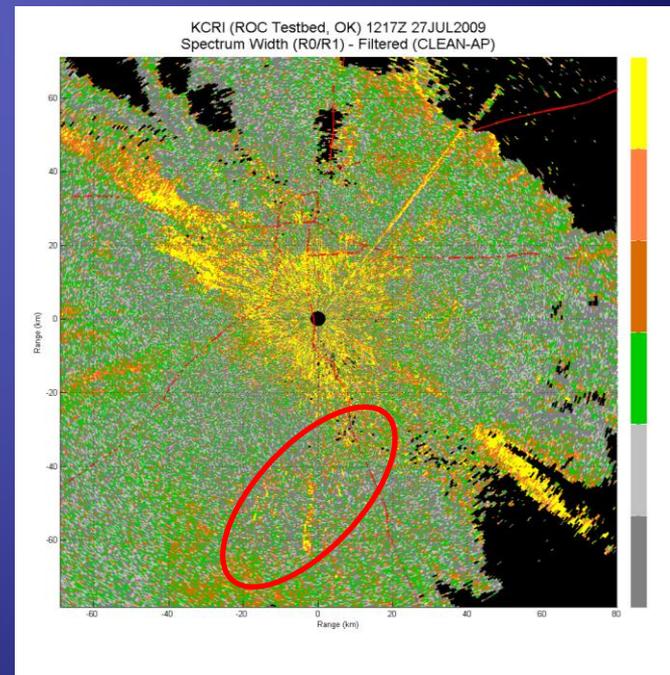
- ◆ NEXRAD Technical Specifications
  - ◆ Detection
    - ◆ ROC tentative (DQ Subcommittee: System Specifications; Chair: Rich Ice)
      - ◆ SP:  $\geq 50\%$  @ -10 dB,  $\geq 90\%$  @ -5 dB, and 100% @ 5 dB
      - ◆ DP:  $\geq 50\%$  @ -15 dB,  $\geq 90\%$  @ -5 dB, and 100% @ 5 dB
      - ◆ May need lower bound -  $\leq 5\%$  @ -30 dB
    - ◆ Clutter Mitigation Decision (CMD) System - NCAR
  - ◆ Filtering
    - ◆ WSR-88D System Specification
      - ◆ Clutter Suppression
        - ◆ Reflectivity – at least 30 dB
        - ◆ Doppler – Range of usable velocities for 20 dB ( $\pm 2$  m/s), 29 dB ( $\pm 3$  m/s), and ( $\pm 4$  m/s) 50 dB
      - ◆ Gaussian Model Adaptive Processing (GMAP™) filter – Vaisala

# KCRI (ROC Testbed) Spectrum Width

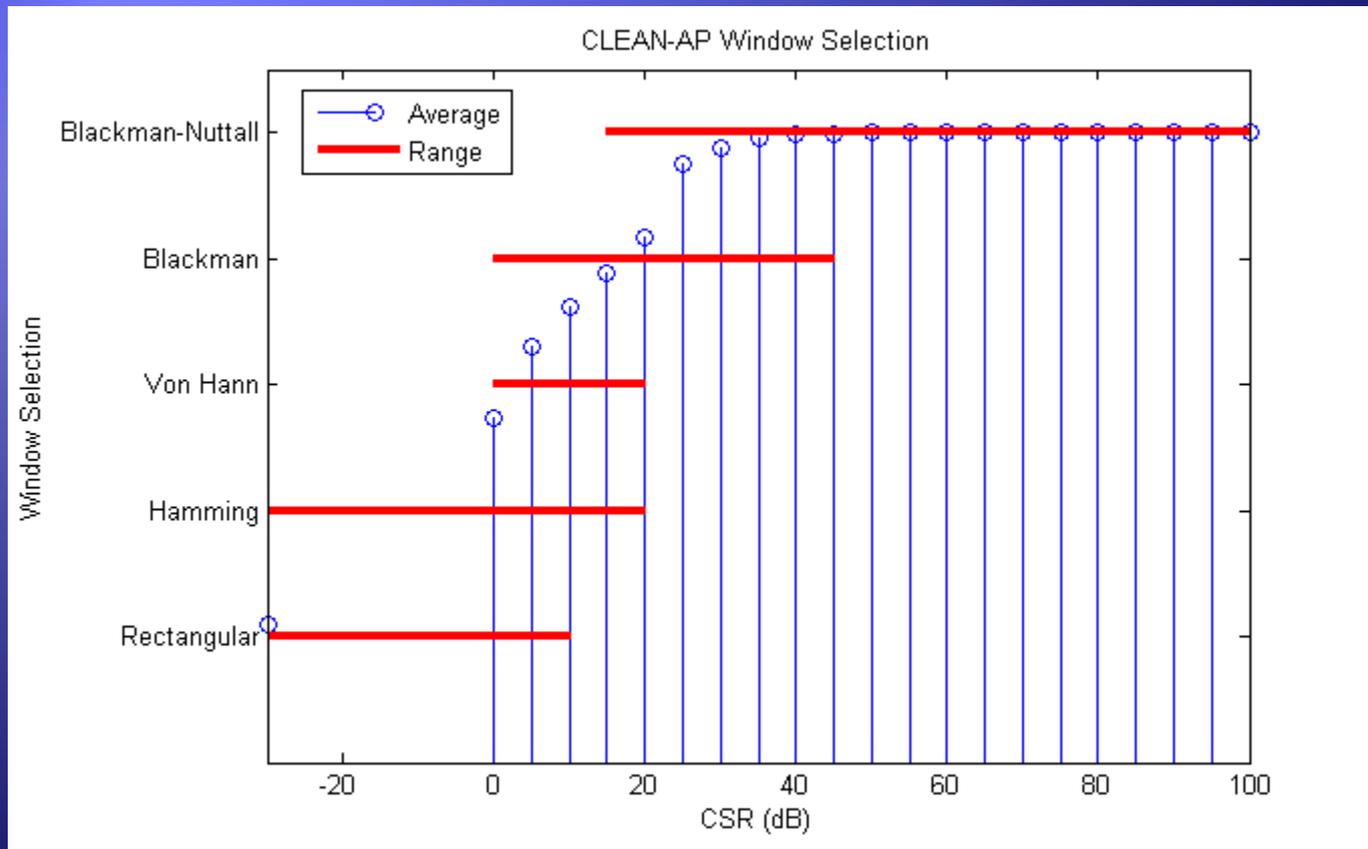
Unfiltered



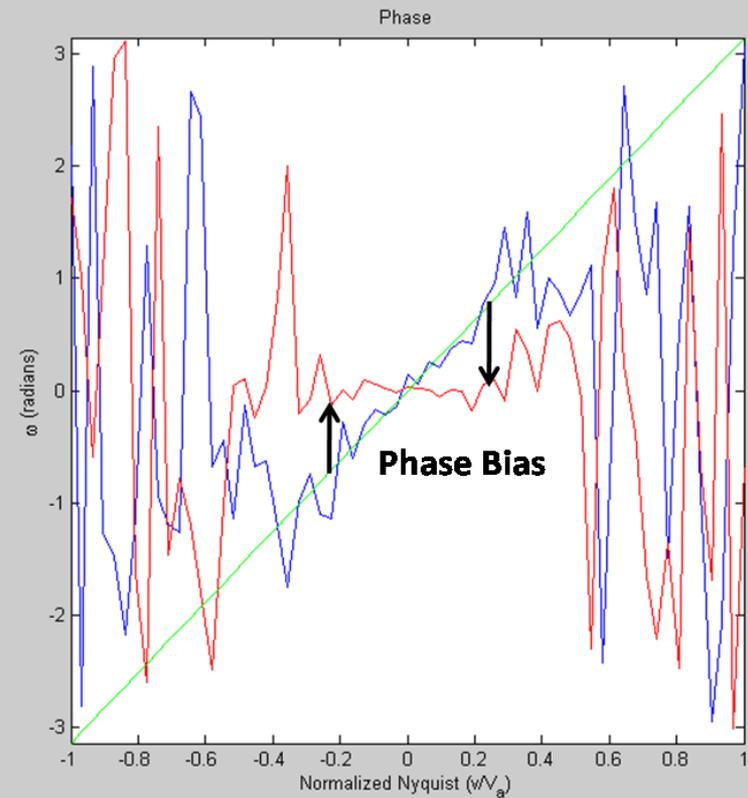
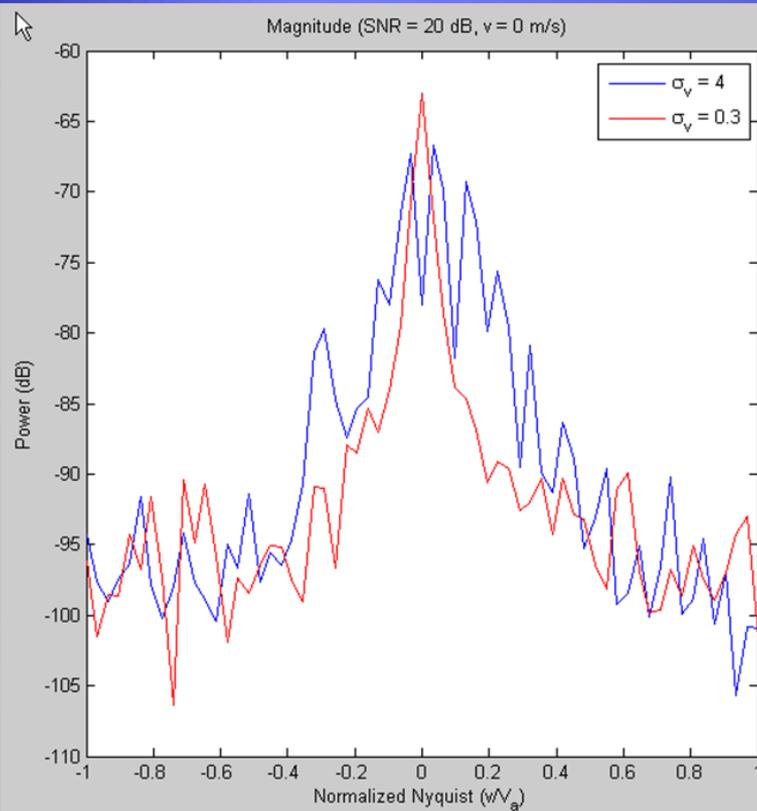
CLEAN-AP



# Adaptive Windowing

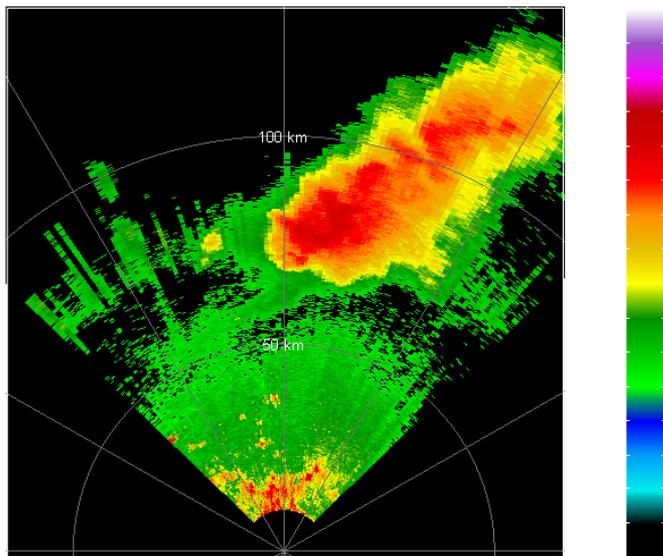


# Phase Bias

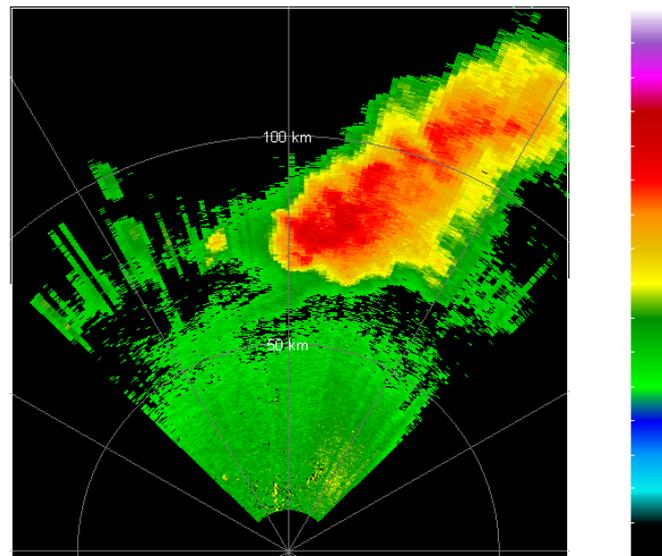


# Reflectivity PAR

Unfiltered

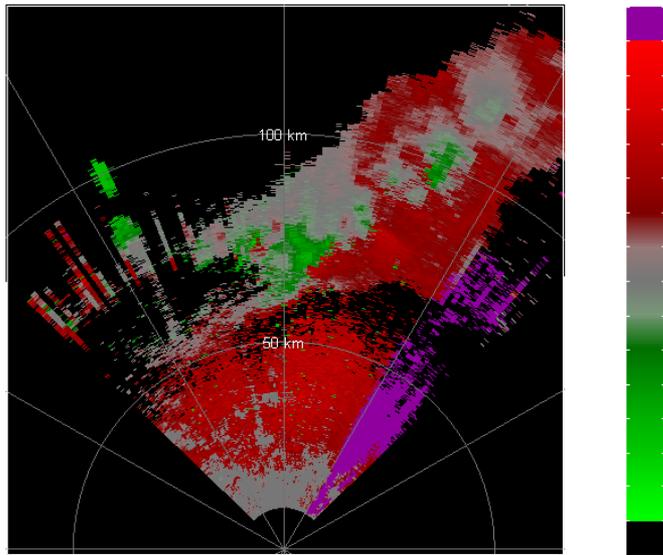


CLEAN-AP

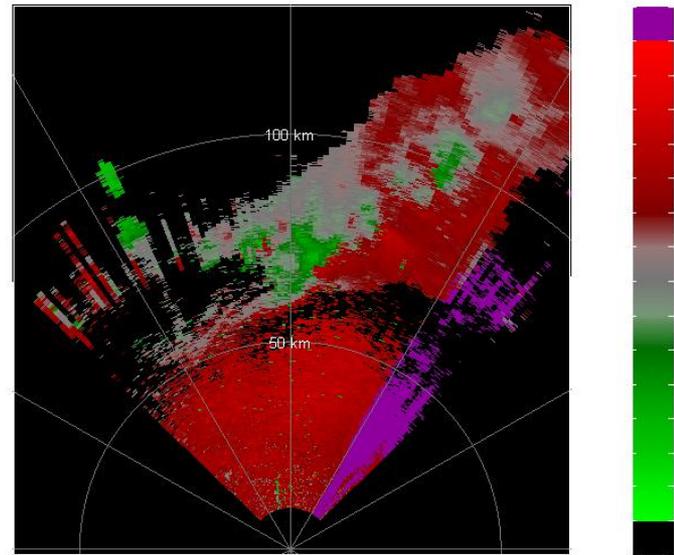


# Velocity PAR

Unfiltered

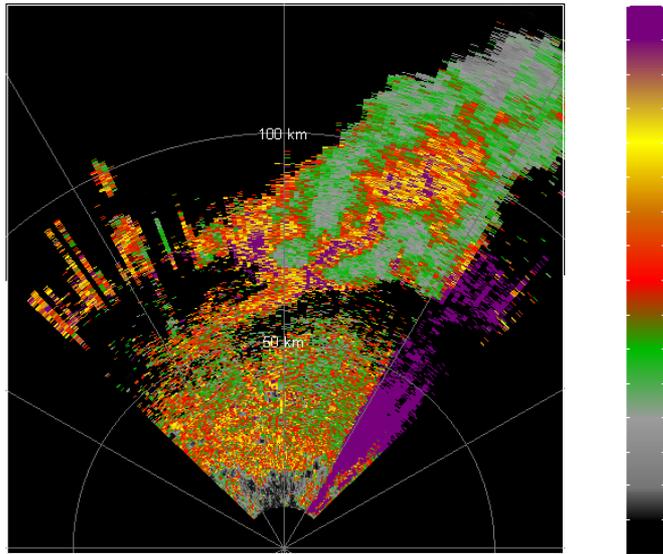


CLEAN-AP

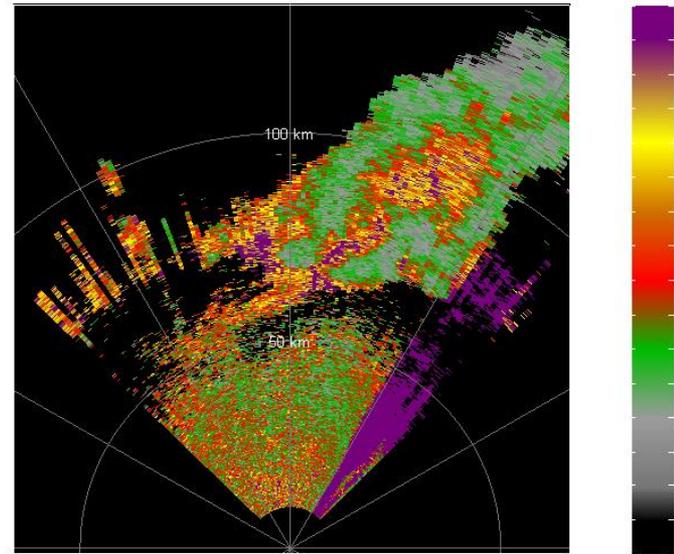


# Spectrum Width PAR

Unfiltered

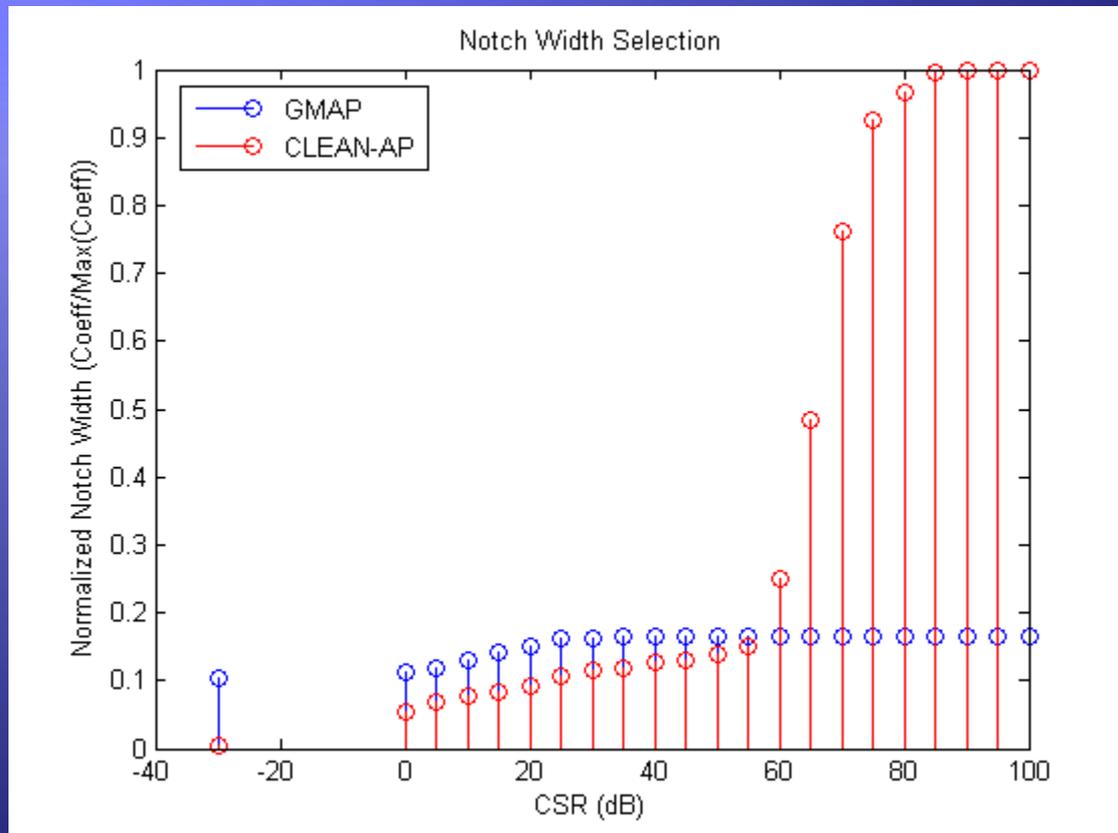


CLEAN-AP



# GMAP vs CLEAN-AP

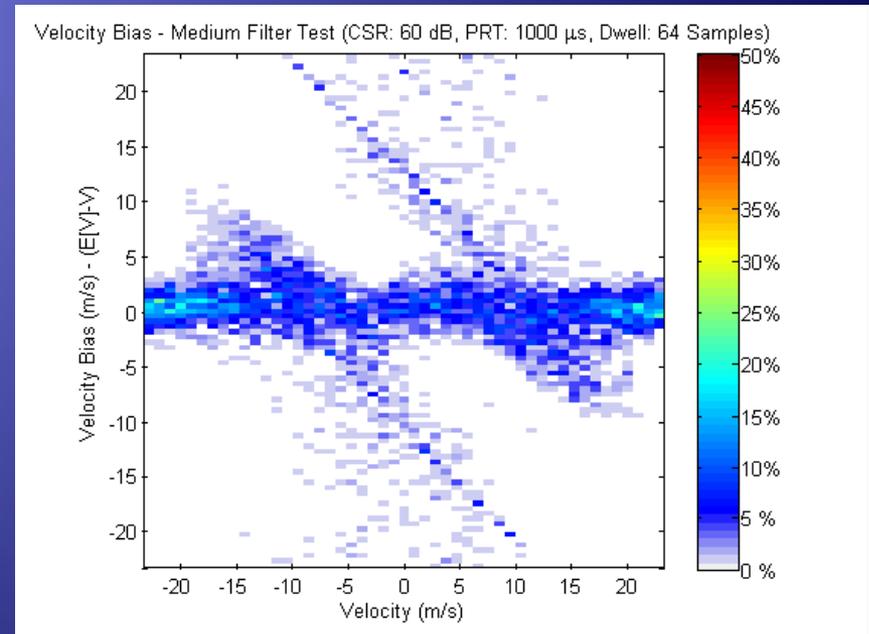
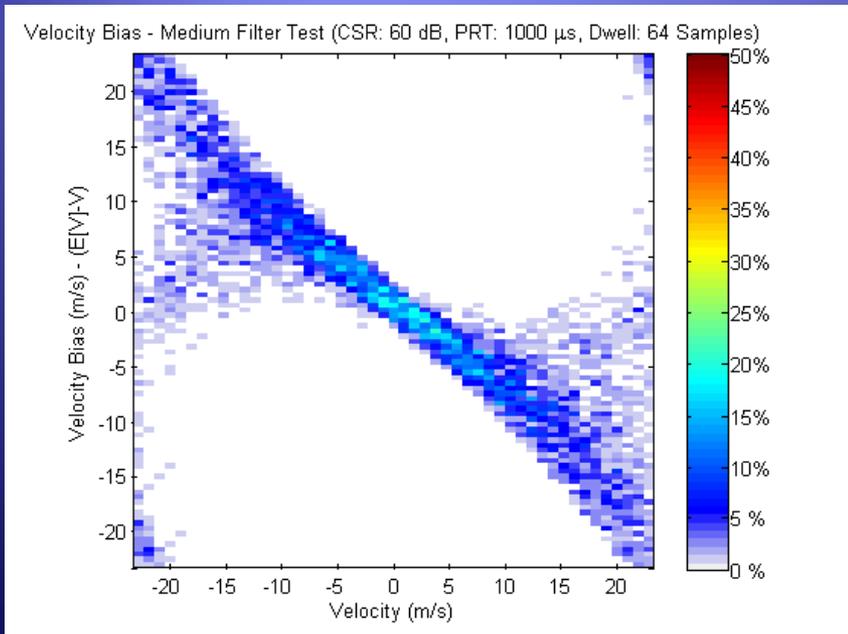
## Notch Width



# Clutter Filtering Velocity Bias Comparison

GMAP

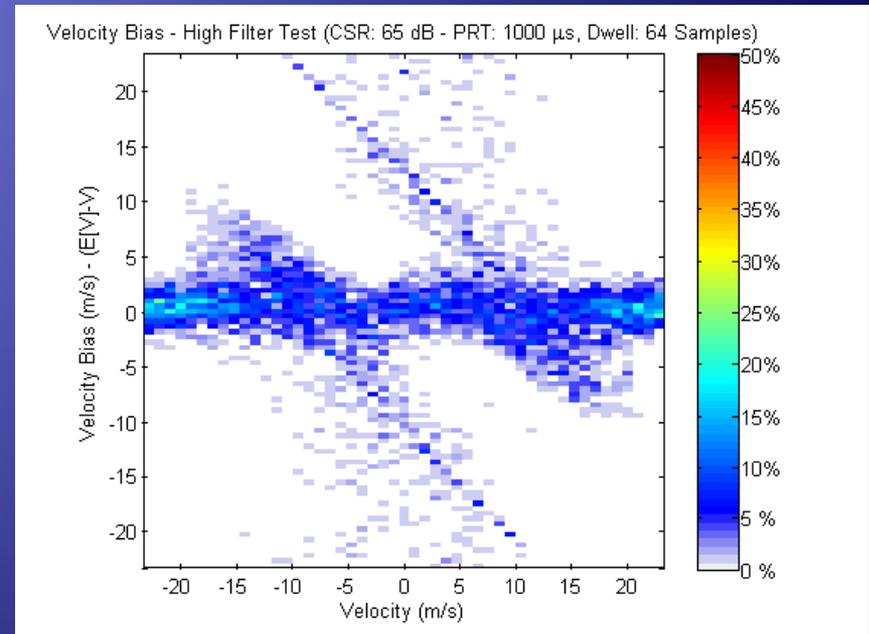
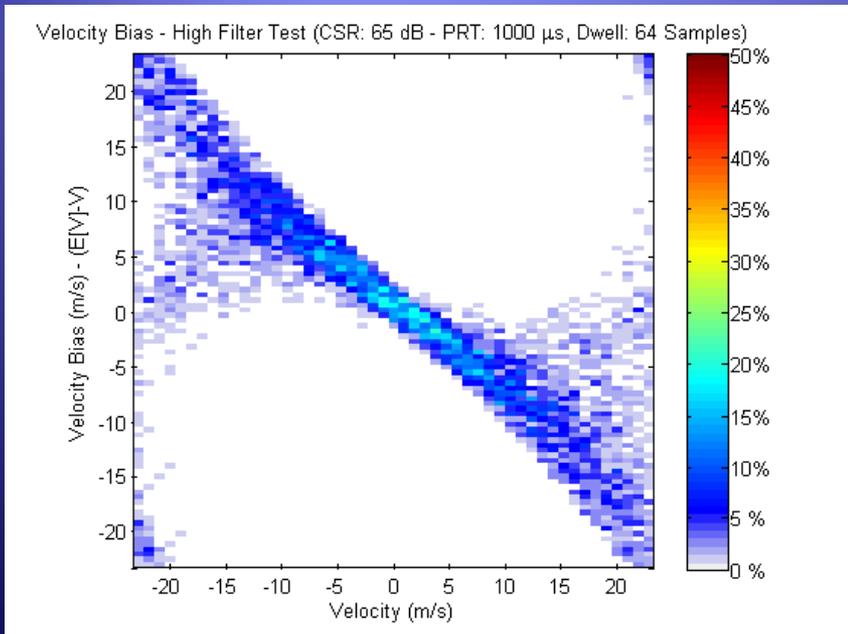
CLEAN-AP



# Clutter Filtering Velocity Bias Comparison

GMAP

CLEAN-AP



# Clutter Suppression Sample Size Analysis

